

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application.

Listing of Claims:

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C | Claim 1. (currently amended) A method for metal smelting[[,]] comprising the steps of:

(A1) preliminarily reducing at least one mixture of raw materials ~~selected from the group consisting of the following (a) through (c)~~ in a prereduction furnace to attain an average metallization degree of from 5 to 55% for ~~metal~~ iron oxide and/or ~~metal~~ iron hydroxide[[;]] , the mixture of raw materials being selected from the group consisting of

(a) a mixture of raw materials prepared by mixing at least a carbonaceous material and ~~a metal~~ an iron oxide and/or ~~a metal~~ an iron hydroxide,

(b) a mixture of raw materials prepared by mixing and granulating at least a carbonaceous material and ~~a metal~~ an iron oxide and/or ~~a metal~~ an iron hydroxide, and

(c) a mixture of raw materials prepared by mixing and molding at least a carbonaceous material and ~~a metal~~ an iron oxide and/or ~~a metal~~ an iron hydroxide; and

(B1) melting and finally reducing the mixture of raw materials, which is preliminarily reduced in the step (A1), by charging ~~thereof~~ said mixture of raw materials to a melting furnace using the carbonaceous material as a reducing agent, and using combustion heat of the carbonaceous material and combustion heat of carbon monoxide generated in the melting furnace as a main heat source.

**Claim 2. (withdrawn)** A method for metal smelting, comprising the steps of: (A2) preliminarily reducing at least one mixture of raw materials selected from the group consisting of following-given (a) through (c) in a prereduction furnace to attain average metallization degree of more than 5% for metal oxide and/or metal hydroxide;

(a) a mixture of raw materials prepared by mixing at least a carbonaceous material and a metal oxide and/or a metal hydroxide,

(b) a mixture of raw materials prepared by mixing and granulating at least a carbonaceous material and a metal oxide and/or a metal hydroxide, and

(c) a mixture of raw materials prepared by mixing and molding at least a carbonaceous material and a metal oxide and/or a metal hydroxide; and

(B2) melting and finally reducing the mixture of raw materials, which is preliminarily reduced in the step (A2), and a metal oxide and/or a metal hydroxide of (i) and/or (ii) given below by charging theretogether to a melting furnace for metal smelting to a degree that the average metallization degree of the total metal oxide and/or the metal hydroxide is in a range of from 5 to 55%, using the carbonaceous material as a reducing agent in the melting furnace, and using combustion heat of the carbonaceous material and combustion heat of carbon monoxide generated in the melting furnace as main heat source;

(i) a metal oxide and/or a metal hydroxide, which have a lower percentage of pre-reduction than that of the mixture of raw materials preliminarily reduced in the step (A2), and

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(ii) a metal oxide and/or a metal hydroxide, which are not preliminarily reduced.

**Claim 3. (withdrawn)** The method for metal smelting of claim 1 or claim 2, wherein the mixture of raw materials at a high temperature discharged from the prereduction furnace after being preliminarily reduced is introduced to a non-open type vessel or a pneumatic conveying unit that is operated by a non-oxidizing gas as a pneumatic conveying gas, and is transferred to the melting furnace using the non-open type vessel or the pneumatic-conveying unit while keeping the mixture to 600°C or higher temperature, then is charged to the melting furnace.

**Claim 4. (withdrawn)** The method for metal smelting of claim 2, wherein the mixture of raw materials, which is preliminarily reduced in the step (A2), and the metal oxide and/or the metal hydroxide of (i) and/or (ii) are mixed together to adjust the average metallization degree of the total metal oxide and/or the metal hydroxide to a range of from 5 to 55%, then the mixture is

charged to the melting furnace for metal smelting.

**Claim 5. (withdrawn)** The method for metal smelting of claim 4, wherein the mixture of raw materials at a high temperature discharged from the prereduction furnace after being preliminarily reduced is introduced to a non-open type vessel or a pneumatic conveying unit that is operated by a non-oxidizing gas as a pneumatic conveying gas, along with the metal oxide and/or the metal hydroxide of (i) and/or (ii), and the introduced mixture is transferred to the melting furnace for charging thereto.

**Claim 6. (withdrawn)** The method for metal ~~melting~~ smelting of claim 1 or claim 2, wherein the percentage of post combustion of a gas generated in the melting furnace is 20% or more.

**Claim 7. (withdrawn)** The method for metal smelting of claim 1 or claim 2, wherein an additional carbonaceous material, other than the carbonaceous material contained in the mixture of raw materials, is charged to the melting furnace.

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**Claim 8. (withdrawn)** The method for metal ~~melting~~ smelting of claim 7, wherein the high temperature mixture of raw materials, which is preliminarily reduced in the step (A1) or the step (A2), [([)] the mixture of raw materials, which is preliminarily reduced in the step (A2), includes a mixture that contains the metal oxide and/or the metal hydroxide of (i) and/or (ii)[(]], is charged to the melting furnace at the same time that the carbonaceous material is charged thereto; and at least a part of each of the charged mixture of raw materials and the carbonaceous material falls down in the furnace to reach to a bath surface.

**Claim 9. (withdrawn)** The method for metal smelting of claim 2, wherein the melting furnace is a metal-bath type smelting reduction furnace.

**Claim 10. (withdrawn)** The method for metal smelting of claim 1 or claim 2, wherein the mixture of raw materials is reduced in a reduction zone of the prereduction furnace, and an

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oxide layer is formed on a surface layer of particles of the mixture of raw materials.

**Claim 11. (withdrawn)** The method for metal smelting of claim 10, wherein ~~the~~ a degree of oxidization of an intrafurnace atmosphere of a part of or total region of the reduction zone of the prereduction furnace is 30% or more.

**Claim 12. (withdrawn)** The method for metal smelting of claim 1 or claim 2, wherein a gas generated in the melting furnace is charged to the prereduction furnace as a combustion gas.

**Claim 13. (withdrawn)** The method for metal smelting of claim 1 or claim 2, wherein a gas, which is generated in the melting furnace and which becomes to lower than 300°C after being discharged from the melting furnace, and/or an oxygen-containing gas being charged to the prereduction furnace are preheated by the sensible heat of a flue gas discharged from the prereduction

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furnace and/or sensible heat of a flue gas obtained by combusting a part of a gas generated in the melting furnace, then are charged to the prereduction furnace.

**Claim 14. (withdrawn)** The method for metal smelting of claim 1 or claim 2, wherein a generated gas  $[(s)]$ , which is generated in the melting furnace and which becomes to lower than 300°C after discharged from the melting furnace, and/or an oxygen-containing support gas  $[(o)]$  being charged to the prereduction furnace are preheated by the steps of (i) and (ii) given below, then are charged to the prereduction furnace:

(i) preheating the generated gas  $[(s)]$  and/or the oxygen-containing support gas  $[(o)]$  by the sensible heat of a flue gas coming from the prereduction furnace to raise the temperature thereof to below 500°C, and

(ii) preheating the generated gas  $[(s)]$  and/or the oxygen-containing support gas  $[(o)]$ , which are preheated in the step (i) by the sensible heat of a flue gas prepared by



combusting a part of the generated gas  $[(s)]$  and/or other fuel to further increase the temperature thereof.

**Claim 15. (withdrawn)** The method for metal smelting of claim 1 or claim 2, wherein at least a part of an auxiliary raw material being charged to the melting furnace is charged to the prereduction furnace along with the mixture of raw materials.

**Claim 16. (withdrawn)** The method for metal smelting of claim 15, wherein at least a part of the auxiliary raw material being charged to the prereduction furnace is a non-burnt auxiliary raw material, and the auxiliary raw material is fired in the prereduction furnace.

**Claim 17. (withdrawn)** The method for metal smelting of claim 1 or claim 2, wherein the mixture of raw materials being charged to the prereduction furnace contains dust recovered from a gas generated in the melting furnace.

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**Claim 18. (withdrawn)** The method for metal smelting of claim 1 or claim 2, wherein the carbonaceous material is classified to individual particle ranges, and the carbonaceous material of fine particle ranges is used as a carbonaceous material to be added to the mixture of raw materials being charged to the prereduction furnace, while the carbonaceous material of coarse particle ranges is used as a carbonaceous material to be charged to the melting furnace.

**Claim 19. (withdrawn)** The method for metal smelting of claim 1 or claim 2, wherein at least a part of the mixture of raw materials being charged to the prereduction furnace or of individual raw materials before preparing the mixture of the raw materials is preliminarily dried using the sensible heat and/or the latent heat of a flue gas discharged from the prereduction furnace and/or of a gas generated in the melting furnace.

**Claim 20. (withdrawn)** The method for metal smelting of claim 1 or claim 2, wherein the prereduction furnace is a rotary

hearth type prereduction furnace, and the preliminary reduction of the mixture of raw materials is conducted while forming a layer of powder and particle layer, which is not discharged from a raw material discharge opening, on a hearth of the rotary type furnace.

**Claim 21. (withdrawn)** The method for metal smelting of claim 1 or claim 2, wherein the prereduction furnace is a rotary hearth type prereduction furnace, and one or more of material selected from the group consisting of a mixture of raw materials, a metal oxide and/or a metal hydroxide, an auxiliary raw material being charged to the melting furnace, and a carbonaceous material, as a coolant onto a layer of raw materials immediately before being discharged from a raw material discharge opening, and treated raw materials are discharged from the furnace in a state that the coolant is mixed thereto using a raw material discharge unit located at the raw material discharge opening.

**Claim 22. (withdrawn)** The method for metal smelting of claim 21, wherein the weight ratio of an amount of Fe (A) in the coolant being charged onto the layer of raw materials to an amount of Fe (B) as an ingredient of the raw material layer, (A)/(B), is in a range of from 1/10 to 1/1.

**Claim 23. (withdrawn)** The method for metal smelting of claim 1 or claim 2, wherein a non-fired auxiliary raw material is fired under the contact with a high temperature flue gas discharged from the prereduction furnace, then is charged to the melting furnace.

**Claim 24. (withdrawn)** The method for metal smelting of claim 23, wherein air is preheated by a high temperature flue gas which was used for firing the non-fired auxiliary raw material, and the preheated air is supplied to the prereduction furnace.

**Claim 25. (withdrawn)** The method for metal smelting of claim 1 or claim 2, wherein the percentage of post combustion of

a gas generated in the melting furnace is 20% or more, and the gas generated in the melting furnace is charged to the prereduction furnace as a combustion gas.

**Claim 26. (withdrawn)** The method for metal smelting of claim 1 or claim 2, wherein a carbonaceous material is charged to the melting furnace adding to the carbonaceous material in the mixture of raw materials, the percentage of post combustion of a gas generated in the melting furnace is 20% or more, and the gas generated in the melting furnace is charged to the prereduction furnace as a combustion gas.

**Claim 27. (withdrawn)** The method for metal smelting of claim 1 or claim 2, wherein at least a part of the mixture of raw materials being charged to the prereduction furnace or at least a part of individual raw materials before preparing the mixture of raw materials is preheated by the sensible heat and/or the latent heat of a flue gas coming from the prereduction furnace and/or a gas generated in the melting furnace, the percentage of post

combustion of the gas generated in the melting furnace is 20% or more, and the gas generated in the melting furnace is charged to the prereduction furnace as a combustion gas.

**Claim 28. (withdrawn)** The method for metal smelting of claim 1 or claim 2, wherein at least a part of the mixture of raw materials being charged to the prereduction furnace or at least a part of individual raw materials before preparing the mixture of raw materials is preheated by the sensible heat and/or the latent heat of a flue gas coming from the prereduction furnace and/or a gas generated in the melting furnace, a carbonaceous material is charged to the melting furnace adding to the carbonaceous material in the mixture of raw materials, the percentage of post combustion of the gas generated in the melting furnace is 20% or more, and the gas generated in the melting furnace is charged to the prereduction furnace as a combustion gas.

**Claim 29. (withdrawn)** The method for metal smelting of claim 1 or claim 2, wherein at least a part of the mixture of raw

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materials being charged to the prereduction furnace or at least a part of individual raw materials before preparing the mixture of raw materials is preheated by the sensible heat and/or the latent heat of a flue gas coming from the prereduction furnace and/or a gas generated in the melting furnace, a carbonaceous material is charged to the melting furnace adding to the carbonaceous material in the mixture of raw materials, the percentage of post combustion of the gas generated in the melting furnace is 20% or more, the gas generated in the melting furnace is charged to the prereduction furnace as a combustion gas, the mixture of raw materials at a high temperature discharged from the prereduction furnace after being preliminarily reduced is introduced to a closed type vessel or a pneumatic conveying unit that is operated by a non-oxidizing gas as a pneumatic conveying gas, and is transferred to the melting furnace using the closed type vessel or the pneumatic conveying unit while keeping the mixture to 600°C or higher temperature, then is charged to the melting furnace.

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**Claim 30. (withdrawn)** A method for metal smelting comprising the steps of:

(A) preliminarily reducing a mixture of one or more of mixture of raw materials selected from the group consisting of following-given (a) through (c) in a prereduction furnace of rotary hearth type until a part of the metal oxide and/or the metal hydroxide is metallized;

(a) a mixture of raw materials prepared by mixing at least a carbonaceous material and a metal oxide-and/or a metal hydroxide,

(b) a mixture of raw materials prepared by mixing and granulating at least a carbonaceous material and a metal oxide and/or a metal hydroxide, and

(c) a mixture of raw materials prepared by mixing and molding at least a carbonaceous material and a metal oxide and/or a metal hydroxide; and

(B) melting and finally reducing the mixture of raw materials, which is preliminarily reduced in the step (A), by charging thereof to a melting furnace using the carbonaceous



material as a reducing agent, and using combustion heat of the carbonaceous material and combustion heat of carbon monoxide generated in the melting furnace as main heat source; wherein the step (A) ~~adopts~~ is carried out in a rotary hearth type prereduction furnace having two or more of raw material charge opening in peripheral direction thereof, and the mixture of raw materials is charged through individual raw material charge openings successively ~~onto~~ into the rotary hearth so ~~as~~ that a layer of raw materials of the mixture of raw materials charged from an upstream side raw material charge opening ~~to be~~ are directly heated by ~~the~~ an intrafurnace atmosphere until the mixture of raw materials is charged from a downstream side raw material charge opening, thus conducting the preliminary reduction of the mixture of raw materials.

**Claim 31. (withdrawn)** The method for metal smelting of claim 30, wherein the step (A) is carried out by preliminarily reducing the mixture of raw materials using a prereduction

furnace having two or more of raw material charge opening in peripheral direction thereof at almost equal pitch.

**Claim 32. (withdrawn)** An apparatus for metal smelting comprising:

a rotary hearth type prereduction furnace having two or more of raw material charge opening in peripheral direction thereof to conduct preliminary reduction by charging one or more of mixture of raw materials selected from the group consisting of (a) through (c),

(a) a mixture of raw materials prepared by mixing at least a carbonaceous materials and a metal oxide and/or a metal hydroxide,

(b) a mixture of raw materials prepared by mixing and granulating at least a carbonaceous material and a metal oxide and/or a metal hydroxide, and

(c) a mixture of raw material prepared by mixing and molding at least a carbonaceous material and a metal oxide and/or a metal hydroxide; and

a melting furnace for metal smelting to melt and finally reduce the mixture of raw materials, which mixture is preliminarily reduced in the prereduction furnace, using the carbonaceous material as a reducing agent and using combustion heat of the carbonaceous material and combustion heat of carbon monoxide generated in the furnace as a main heat source.

**Claim 33. (withdrawn)** The apparatus for metal smelting of claim 32, further comprising a firing furnace to fire an auxiliary raw material, being charged to the melting furnace, by contacting thereof with an introduced high temperature flue gas discharged from the prereduction furnace.

**Claim 34. (withdrawn)** The apparatus for metal smelting of claim 32 or claim 33, wherein two or more of raw material charge opening are located in peripheral direction of the prereduction furnace at almost equal pitch.

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**Claim 35. (withdrawn)** A method for melt smelting,  
comprising the steps of:

(A) preliminarily reducing a mixture of one or more of  
mixture of raw materials selected from the group consisting of  
following-given (a) through (c) in a prereduction furnace of a  
rotary hearth type until a part of the metal oxide and/or the  
metal hydroxide is metallized;

(a) a mixture of raw materials prepared by mixing at least a  
carbonaceous material and a metal oxide and/or a metal hydroxide,

(b) a mixture of raw materials prepared by mixing and  
granulating at least a carbonaceous material and a metal oxide  
and/or a metal hydroxide, and

(c) a mixture of raw materials prepared by mixing and  
molding at least a carbonaceous material and a metal oxide and/or  
a metal hydroxide; and

(B) melting and finally reducing the mixture of raw  
materials, which is preliminarily reduced in the step (A), by  
charging thereof to a melting furnace using the carbonaceous  
material as a reducing agent, and using combustion heat of the

carbonaceous material and combustion heat of carbon monoxide generated in the melting furnace as main heat source;

wherein the step (A) conducts a preliminary reduction of the mixture of raw materials while forming a layer that ~~contains~~ does not contain a large amount of metal oxide and/or metal hydroxide at ~~the~~ a lowermost layer part of the raw material layer on the rotary hearth of the prereduction furnace.

**Claim 36. (withdrawn)** The method of metal smelting of claim 35, wherein the lowermost layer part of the raw material layer consists of an auxiliary raw material or consists ~~mainly~~ of a layer of auxiliary material being charged to the melting furnace.

**Claim 37. (withdrawn)** A method for metal smelting comprising the steps of:

(A) preliminarily reducing a mixture of one or more of mixture of raw materials selected from the group consisting of following-given (a) through (c) in a prereduction furnace of

a rotary hearth type until a part of the metal oxide and/or the metal hydroxide is metallized;

(a) a mixture of raw materials prepared by mixing at least a carbonaceous material and a metal oxide and/or a metal hydroxide,

(b) a mixture of raw materials prepared by mixing and granulating at least a carbonaceous material and a metal oxide and/or a metal hydroxide, and

(c) a mixture of raw materials prepared by mixing and molding at least a carbonaceous material and a metal oxide and/or a metal hydroxide; and

(B) melting and finally reducing the mixture of raw materials, which is preliminarily reduced in the step (A), by charging thereof to a melting furnace using the carbonaceous material as a reducing agent, and using combustion heat of the carbonaceous material and combustion heat of carbon monoxide generated in the melting furnace as main heat source;

wherein, in the step (A), a charge consisting mainly of a powder and particle raw material  $[[()]]$   $\perp$  one or more of raw material selected from the group consisting of a mixture of raw

materials, a metal oxide and/or a metal hydroxide, and a carbonaceous material[[]]] and/or a charge consisting ~~mainly~~ of powder and particles of an auxiliary raw material being charged to the melting furnace, or a charge consisting ~~mainly~~ of powder and particles of the powder and particle raw material and/or the powder and particles of the auxiliary raw material, is charged ~~onto~~ into the rotary hearth of the prereduction furnace, then granulates and/or molded forms of the mixture of raw materials are supplied to ~~the~~ an upper layer of the charge at a downstream side along ~~the~~ a route of rotary hearth movement.

**Claim 38. (withdrawn)** The method for metal smelting of claim 37, wherein, in the step (A), the particle size of the charge of powder and particles being charged ~~onto~~ into the rotary hearth is in a range of from 0.05 to 10 mm.

**Claim 39. (withdrawn)** The method for metal smelting of claim 37 or claim 38, wherein, in the step (A), the powder and

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particle charge being charged ~~onto~~ into the rotary hearth is coal or a charge consisting ~~mainly~~ of coal.

**Claim 40. (withdrawn)** The method for metal smelting of claim 37 or claim 38, wherein, in the step (A), the powder and particle charge being charged ~~onto~~ into the rotary hearth is a non-fired auxiliary raw material or a charge consisting ~~mainly~~ of a non-fired auxiliary raw material.

**Claim 41. (withdrawn)** The method for metal smelting of claim 37 or claim 38, wherein, in the step (A), granulates and/or molded forms of a mixture of raw materials which are charged to the upper layer of the charge on the rotary hearth are granulates and/or molded forms which are not treated by preliminary drying.

**Claim 42. (withdrawn)** A method for metal smelting, comprising the steps of:

(A) preliminarily reducing a mixture of one or more of mixture of raw materials selected from the group consisting of



following-given (a) through (c) in a prereduction furnace until a part of the metal oxide and/or the metal hydroxide is metallized;

(a) a mixture of raw materials prepared by mixing at least a carbonaceous material and a metal oxide and/or a metal hydroxide,

(b) a mixture of raw materials prepared by mixing and granulating at least a carbonaceous material and a metal oxide and/or a metal hydroxide, and

(c) a mixture of raw materials prepared by mixing and molding at least a carbonaceous material and a metal oxide and/or a metal hydroxide;

(B) melting and finally reducing the mixture of raw materials, which is preliminarily reduced in the step (A), by charging thereof to a melting furnace using the carbonaceous material as a reducing agent, and using combustion heat of the carbonaceous material and combustion heat of carbon monoxide generated in the melting furnace as main heat source; and

(C) firing a non-fired auxiliary raw material being charged to the melting furnace by contacting thereof with a high temperature flue gas discharged from the prereduction furnace.

**Claim 43. (withdrawn)** The method for metal smelting of claim 42, wherein air is preheated by the high temperature flue gas that ~~was~~ is used for firing the auxiliary raw material, and the preheated air is supplied to the prereduction furnace.

**Claim 44. (withdrawn)** An apparatus for metal smelting comprising:

a prereduction furnace to conduct preliminary reduction by charging one or more of mixture of raw materials selected from the group consisting of (a) through (c),

(a) a mixture of raw materials prepared by mixing at least a carbonaceous material and a metal oxide and/or a metal hydroxide,

(b) a mixture of raw materials prepared by mixing and granulating at least a carbonaceous material and a metal oxide and/or a metal hydroxide, and

(c) a mixture of raw materials prepared by mixing and molding at least a carbonaceous material and a metal oxide and/or a metal hydroxide;

a firing furnace for firing a non-fired auxiliary raw material being charged to a melting furnace for metal smelting by contacting thereof with a high temperature flue gas discharged from the prereduction furnace; and

a melting furnace for metal smelting to melt and finally reduce the mixture of raw materials, which is preliminarily reduced in the prereduction furnace, using a carbonaceous material as a reducing agent and using combustion heat of the carbonaceous material and combustion heat of carbon monoxide generated in the furnace as main heat source.

**Claim 45. (withdrawn)** A method for metal smelting comprising the steps of:

(A) preliminarily reducing one or more of the mixture of mixture of raw materials selected from the group consisting of (a) through (c) in a prereduction furnace of a rotary hearth type, a horizontally moving hearth type, a multi-hearth type, or a rotary kiln type until a part of a metal oxide and/or a metal hydroxide is metallized,

(a) a mixture of raw materials prepared by mixing at least a carbonaceous material and a metal oxide and/or a metal hydroxide,

(b) a mixture of raw materials prepared by mixing and granulating at least a carbonaceous material and a metal oxide and/or a metal hydroxide, and

(c) a mixture of raw materials prepared by mixing and molding at least a carbonaceous material and a metal oxide and/or a metal hydroxide; and

(B) melting and finally reducing the mixture of raw materials, which is preliminarily reduced in the step (A), by charging thereof to a melting furnace using the carbonaceous material as a reducing agent, and using combustion heat of the carbonaceous material and combustion heat of carbon monoxide generated in the melting furnace as main heat source;

wherein the metal oxide and/or the metal hydroxide in the mixture of raw materials ~~are~~ is an ore prepared by applying primary crushing to an ore consisting ~~mainly~~ of a sinter-feed ore.

**Claim 46. (withdrawn)** A method for metal smelting,  
comprising the steps of:

(A) preliminarily reducing a mixture of one or more of  
mixture of raw materials selected from the group consisting of  
following-given (a) through (c) in a prereduction furnace of a  
rotary hearth type or a horizontally moving hearth type until a  
part of the metal oxide and/or the metal hydroxide is metallized;

(a) a mixture of raw materials prepared by mixing at least a  
carbonaceous material and a metal oxide and/or a metal hydroxide,

(b) a mixture of raw materials prepared by mixing and  
granulating at least a carbonaceous material and a metal oxide  
and/or a metal hydroxide, and

(c) a mixture of raw materials prepared by mixing and  
molding at least a carbonaceous material and a metal oxide and/or  
a metal hydroxide; and

(B) melting and finally reducing the mixture of raw  
materials, which is preliminarily reduced in the step (A), by  
charging thereof to a melting furnace using the carbonaceous  
material as a reducing agent, and using combustion heat of the

carbonaceous material and combustion heat of carbon monoxide generated in the melting furnace as main heat source;

wherein the heating of the mixture of raw materials in the step (A) is conducted by contacting a flame of a heating burner with at least a part of ~~the~~ a top surface of the layer of mixture of raw materials.

**Claim 47. (withdrawn)** An apparatus for metal smelting comprising:

a prereduction furnace of rotary hearth type or horizontally moving hearth type conducting preliminary reduction of a mixture of one or more of mixture of raw materials selected from the group consisting of following-given (a) through (c),

(a) a mixture of raw materials prepared by mixing at least a carbonaceous material and a metal oxide and/or a metal hydroxide,

(b) a mixture of raw materials prepared by mixing and granulating at least a carbonaceous material and a metal oxide and/or a metal hydroxide, and

(c) a mixture of raw materials prepared by mixing and molding at least a carbonaceous material and a metal oxide and/or a metal hydroxide; and

a melting furnace for metal smelting to melt and finally reduce the mixture of raw materials, which is preliminarily reduced in the prereduction furnace, using the carbonaceous material as a reducing agent and using combustion heat of the carbonaceous material and combustion heat of carbon monoxide generated in the furnace as main heat source;

wherein a heating burner for heating the mixture of raw materials charged on the hearth of the prereduction furnace is located in a mode of (i), (ii), or (iii) given below so as a flame of the burner to contact with at least a part of the top surface of layer of the mixture of raw materials,

(i) a burner tuyere being located at lower part of sidewall of the furnace body,

(ii) a burner tuyere being located on sidewall of the furnace body, and being tilted by  $45^{\circ}$  downward from horizontal plane toward the hearth, or

(iii) a burner tuyere being located on ceiling facing down.

**Claim 48. (withdrawn)** A method for metal smelting,  
comprising the steps of:

(A) preliminarily reducing a mixture of one or more of mixture of raw materials selected from the group consisting of following-given (a) through (c) in a prereduction furnace of a rotary hearth type or a horizontally moving hearth type until a part of the metal oxide and/or the metal hydroxide is metallized;

(a) a mixture of raw materials prepared by mixing at least a carbonaceous material and a metal oxide and/or a metal hydroxide,

(b) a mixture of raw materials prepared by mixing and granulating at least a carbonaceous material and a metal oxide and/or a metal hydroxide, and

(c) a mixture of raw materials prepared by mixing and molding at least a carbonaceous material and a metal oxide and/or a metal hydroxide; and

(B) melting and finally reducing the mixture of raw materials, which is preliminarily reduced in the step (A), by



charging thereof to a melting furnace using the carbonaceous material as a reducing agent, and using combustion heat of the carbonaceous material and combustion heat of carbon monoxide generated in the melting furnace as main heat source;

wherein, in the step (A), the mixture of raw materials charged ~~onto~~ into the hearth of the prereduction furnace is rotated and/or transferred against the hearth during the stage of heating and reducing thereof.

**Claim 49. (withdrawn)** An apparatus for metal smelting, comprising:

a prereduction furnace of rotary hearth type or horizontally moving hearth type conducting preliminary reduction of a mixture of one or more of mixture of raw materials selected from the group consisting of following-given (a) through (c),

(a) a mixture of raw materials prepared by mixing at least a carbonaceous material and a metal oxide and/or a metal hydroxide,

(b) a mixture of raw materials prepared by mixing and granulating at least a carbonaceous material and a metal oxide

and/or a metal hydroxide, and

(c) a mixture of raw materials prepared by mixing and molding at least a carbonaceous material and a metal oxide and/or a metal hydroxide; and

a melting furnace for metal smelting to melt and finally reduce the mixture of raw materials, which is preliminarily reduced in the prereduction furnace, using the carbonaceous material as a reducing agent and using combustion heat of the carbonaceous material and combustion heat of carbon monoxide generated in the furnace as main heat source;

wherein the prereduction furnace is provided with a means to rotate and/or transfer the mixture of raw materials on the hearth against the hearth during the stage of heating and reducing thereof.

**Claim 50. (withdrawn)** The apparatus for metal smelting of claim 49, wherein the means to rotate and/or transfer the mixture of raw materials against the hearth of the prereduction furnace

is a screw unit that can vary the rotational speed of screw shaft.

**Claim 51. (withdrawn)** A method for metal smelting, comprising the steps of:

(A) preliminarily reducing a mixture of one or more of mixture of raw materials selected from the group consisting of following-given (a) through (c) in a prereduction furnace of a rotary hearth type, a horizontally moving hearth type, a multihearth type, or a rotary kiln type until a part of the metal oxide and/or the metal hydroxide is metallized;

(a) a mixture of raw materials prepared by mixing at least a carbonaceous material and a metal oxide and/or a metal hydroxide,

(b) a mixture of raw materials prepared by mixing and granulating at least a carbonaceous material and a metal oxide and/or a metal hydroxide, and

(c) a mixture of raw materials prepared by mixing and molding at least a carbonaceous material and a metal oxide and/or a metal hydroxide; and

(B) melting and finally reducing the mixture of raw materials, which is preliminarily reduced in the step (A), by charging thereof to a melting furnace using the carbonaceous material as a reducing agent, and using combustion heat of the carbonaceous material and combustion heat of carbon monoxide generated in the melting furnace as main heat source;

wherein, at least a part of high temperature gas generated in the melting furnace in the step (B) is injected into a heating burner of the prereduction furnace as a fuel gas using an injector action that uses a combustion air and/or a gas generated in the melting furnace after removing dust therefrom and after pressurized thereto.

**Claim 52. (withdrawn)** A method for metal smelting, comprising the steps of:

(A) preliminarily reducing a mixture of one or more of mixture of raw materials selected from the group consisting of following-given (a) through (c) in a prereduction furnace of a rotary hearth type, a horizontally moving hearth type, a

multihearth type, or a rotary kiln type until a part of the metal oxide and/or the metal hydroxide is metallized;

(a) a mixture of raw materials prepared by mixing at least a carbonaceous material and a metal oxide and/or a metal hydroxide,

(b) a mixture of raw materials prepared by mixing and granulating at least a carbonaceous material and a metal oxide and/or a metal hydroxide, and

(c) a mixture of raw materials prepared by mixing and molding at least a carbonaceous material and a metal oxide and/or a metal hydroxide; and

(B) melting and finally reducing the mixture of raw materials, which is preliminarily reduced in the step (A), by charging thereof to a melting furnace using the carbonaceous material as a reducing agent, and using combustion heat of the carbonaceous material and combustion heat of carbon monoxide generated in the melting furnace as main heat source;

wherein, at least a part of the gas generated in the melting furnace in the step (B) is cooled to 800°C or lower temperature, and is introduced to a high temperature dust removal unit to

remove dust therefrom, then is supplied to a heating burner of the prereduction furnace as a fuel gas in a high temperature state.

**Claim 53. (withdrawn)** A method for metal smelting, comprising the steps of:

(A) preliminarily reducing a mixture of one or more of mixture of raw materials selected from the group consisting of following-given (a) through (c) in a prereduction furnace of a rotary hearth type or a horizontally moving hearth type until a part of the metal oxide and/or the metal hydroxide is metallized;

(a) a mixture of raw materials prepared by mixing at least a carbonaceous material and a metal oxide and/or a metal hydroxide,

(b) a mixture of raw materials prepared by mixing and granulating at least a carbonaceous material and a metal oxide and/or a metal hydroxide, and

(c) a mixture of raw materials prepared by mixing and molding at least a carbonaceous material and a metal oxide and/or a metal hydroxide; and

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(B) melting and finally seducing the mixture of raw materials, which is preliminarily reduced in the step (A), by charging thereof to a melting furnace using the carbonaceous material as a reducing agent, and using combustion heat of the carbonaceous material and combustion heat of carbon monoxide generated in the melting furnace as main heat source;

wherein, the prereduction furnace in the step (A) is provided with a tubular flame burner as a heating means, and a gas generated in the step (B) in the melting furnace is supplied to the tubular flame burner as a fuel gas.

**Claim 54. (withdrawn)** The method for metal smelting of claim 53, wherein the gas generated in the melting furnace is supplied to the tubular flame burner of the prereduction furnace after removing dust therefrom.

**Claim 55. (withdrawn)** The method for metal smelting of claim 53 or claim 54, wherein the gas generated in the melting

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furnace is stored in a gas holder, and is supplied from the gas holder to the tubular flame burner of the prereduction furnace.

**Claim 56. (withdrawn)** A method for metal smelting, comprising the steps of:

(A) preliminarily reducing a mixture of one or more of mixture of raw materials selected from the group consisting of the following-given (a) through (c) in a prereduction furnace of a rotary hearth type, a horizontally moving hearth type, a multihearth type, or a rotary kiln type until a part of the metal oxide and/or the metal hydroxide is metallized;

(a) a mixture of raw materials prepared by mixing at least a carbonaceous material and a metal oxide and/or a metal hydroxide,

(b) a mixture of raw materials prepared by mixing and granulating at least a carbonaceous material and a metal oxide and/or a metal hydroxide, and

(c) a mixture of raw materials prepared by mixing and molding at least a carbonaceous material and a metal oxide and/or a metal hydroxide; and



(B) melting and finally reducing the mixture of raw materials, which is preliminarily reduced in the step (A), by charging thereof to a melting furnace using the carbonaceous material as a reducing agent, and using combustion heat of the carbonaceous material and combustion heat of carbon monoxide generated in the melting furnace as a main heat source;

wherein the mixture of raw materials charged to the prereduction furnace in the step (A) is heated and reduced after dried by preheating thereof with a preheating gas.

**Claim 57. (withdrawn)** The method for metal smelting of claim 56, wherein the prereduction furnace is divided into (i) a preheating and drying zone and (ii) a heating and reducing zone beginning from the raw material charge section side; and the mixture of raw materials is preheated and dried in the preheating and drying zone, then is heated and reduced in the heating and reducing zone.

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**Claim 58. (withdrawn)** The method for metal smelting of claim 57, wherein the preheating gas is a gas generated in the melting furnace, a gas discharged from the heating and reducing zone of the prereduction furnace, or a oxygen-containing support gas which was preheated by the sensible heat of one or more of said gases.

**Claim 59. (withdrawn)** The method for metal smelting of claim 56 or claim 57, wherein the temperature of the preheating gas is in a range of from 100 to 400°C.

**Claim 60. (withdrawn)** A method for metal smelting, comprising the steps of:

(A) preliminarily reducing a mixture of one or more of mixture of raw materials selected from the group consisting of following-given (a) through (c) in a prereduction furnace of a rotary hearth type or a horizontally moving hearth type until a part of the metal oxide and/or the metal hydroxide is metallized;

(a) a mixture of raw materials prepared by mixing at least a carbonaceous material and a metal oxide and/or a metal hydroxide,

(b) a mixture of raw materials prepared by mixing and granulating at least a carbonaceous material and a metal oxide and/or a metal hydroxide, and

(c) a mixture of raw materials prepared by mixing and molding at least a carbonaceous material and a metal oxide and/or a metal hydroxide; and

(B) melting and finally reducing the mixture of raw materials, which is preliminarily reduced in the step (A), by charging thereof to a melting furnace using the carbonaceous material as a reducing agent, and using combustion heat of the carbonaceous material and combustion heat of carbon monoxide generated in the melting furnace as a main heat source;

wherein, on charging a raw material comprising a mixture of raw materials and/or a carbonaceous material to a bath of the melting furnace in the step (B), the raw material is charged to a bath surface region where a descending flow appears in a slag bath section.

**Claim 61. (withdrawn)** An apparatus for metal smelting comprising:

a prereduction furnace of rotary hearth type or horizontally moving hearth type conducting preliminary reduction of a mixture of one or more of mixture of raw materials selected from the group consisting of following-given (a) through (c),

(a) a mixture of raw materials prepared by mixing at least a carbonaceous material and a metal oxide and/or a metal hydroxide,

(b) a mixture of raw materials prepared by mixing and granulating at least a carbonaceous material and a metal oxide and/or a metal hydroxide, and

(c) a mixture of raw materials prepared by mixing and molding at least a carbonaceous material and a metal oxide and/or a metal hydroxide;

a melting furnace for metal smelting to melt and finally reduce the mixture of raw materials, which is preliminarily reduced in the prereduction furnace, using a carbonaceous material as a reducing agent and using combustion heat of the

carbonaceous material and combustion heat of carbon monoxide generated in the furnace as main heat source; and

a transfer unit to transfer a container, to which the raw material discharged from the prereduction furnace, to a raw material receiving hopper of the melting furnace;

the melting furnace being equipped with one or more of raw material receiving hopper to which the raw material transferred from the prereduction furnace is introduced, and equipped with a hoist which hoists the container and runs on a track to transfer the container, the hoist coming and going only one direction on the track, the container hoisting position at the prereduction furnace side being located at directly beneath the track, the raw material receiving hopper at the melting furnace side being located at directly beneath the track, thus transferring the container between the prereduction furnace and the melting furnace using the hoist that moves along the track.

**Claim 62. (withdrawn)** The apparatus for metal smelting of claim 61 comprising one unit of melting furnace and two units of

prereduction furnace, the container hoisting positions of the two prereduction furnace sides being located at opposite sides therein to the raw material receiving hopper at the melting furnace side or to the raw material receiving hopper group.

**Claim 63. (withdrawn)** The apparatus for metal smelting of claim 61, wherein the container hoist positioned at the prereduction furnace side is a pair to each prereduction furnace.

**Claim 64. (withdrawn)** The apparatus for metal smelting of claim 61, further comprising a turntable that can place plurality of containers thereon and by which the plurality of containers can be successively moved to the raw material discharge opening position of the prereduction furnace and to the container hoisting position by the rotation of the turntable.

**Claim 65. (withdrawn)** The apparatus for metal smelting of claim 61, wherein the melting furnace is a metal-bath type melt-reduction furnace.

**Claim 66. (withdrawn)** The apparatus for metal smelting of claim 61, further comprising a driving mechanism of the hoist for hoisting the container, the driving mechanism comprising:

sheaves ( $Sa_1$ ) and ( $Sa_2$ ) being located at respective longitudinal ends of the track of the hoist;

a sheave ( $Sb$ ) being located on the hoist;

a container suspension means being suspended from the hoist in ascending and descending mode;

a sheave ( $Sc$ ) being mounted to the container suspension means in ascending and descending mode;

a wire-winding drum ( $Da$ ) for hoisting a container located below the track of the hoist;

a wire rope ( $Wa$ ) for hoisting container, which wire rope is unwound from the wire-winding drum ( $Da$ ) and is guided to each sheave, the front end thereof being fixed to an end of the track;

wherein the wire rope ( $Wa$ ) guided from the sheave ( $Sa_1$ ) or ( $Sa_2$ ) is successively guided through the sheave ( $Sb$ ) on the hoist, the sheave ( $Sc$ ) on the container suspension means, and the sheave ( $Sb$ ) on the hoist, then is guided to the sheave ( $Sa_2$ ) or

(Sa<sub>1</sub>), thus the container suspension means is suspended by the wire rope (Wa), and the winding and unwinding action of wire rope (Wa) by the wire-winding drum (Da) makes possible to ascend and descend the container suspension means.

**Claim 67. (withdrawn)** The apparatus for metal smelting of claim 66, further comprising:

a wire-winding drum (Db) for counter weight use, mounted coaxially with the wire-winding drum (Da);

a wire rope (Wb) which is wound in reverse direction to the winding direction of wire rope (Wa) on the wire-winding drum (Da) and which is guided by a sheave located at upper position than the wire-winding drum (Db); and

a counter weight (Co) attached to the front end of the wire rope (Wb).

**Claim 68. (withdrawn)** The apparatus for metal smelting of claim 67, wherein there are located each pair of the sheaves (Sa<sub>1</sub>) and (Sa<sub>2</sub>) positioned at respective longitudinal ends of the



track of the hoist, the sheave (Sc) mounted to the container suspension means, the wire-winding drum (Da) for hoisting container, the wire-winding drum (Db) for counter weight use, the wire rope (Wa) for hoisting container, the wire rope (Wb) being wound by the wire-winding drum (Db), and the counter weight (Co) attached to the front end of the wire rope (Wb).

**Claim 69. (withdrawn)** The method for metal smelting of claim 45, wherein the primarily crushed ore has particle sizes of from 0.1 to 1 mm.

**Claim 70. (new)** The method for metal smelting according to claim 1, further comprising the steps of determining the average metallization degree based on production rate, energy consumption and energy balance in a process of manufacturing molten iron.

**Claim 71. (new)** The method for metal smelting according to claim 1, wherein the average metallization degree is from 5 to 40%.

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**Claim 72. (new)** The method for metal smelting according to claim 71, wherein the average metallization degree is from 10 to 30%.

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